Can Machines Be Creative?

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What Is Creativity?

- From dictionaries:
  - The use of the imagination or original ideas, especially in the production of an artistic work
  - The ability to transcend traditional ideas, rules, patterns, relationships, or the like, and to create meaningful new ideas, forms, methods, interpretations, etc

- Typically difficult to define in objective terms
Creativity in Computational Terms

- Newell, Shaw and Simon's definition
  a. Answer is novel and useful
  b. Answer demands that we reject ideas we had previously accepted
  c. Answer results from intense motivation and persistence
  d. Answer comes from clarifying a problem that was originally vague

- Still non-objective terms, but "a." is considered must-have
Creative Generation and Evaluation

• Generation
  ○ Placing familiar/unfamiliar objects to unfamiliar/familiar settings
  ○ Blending two superficially different objects
  ○ Comparing a familiar object to an unrelated concept
  ○ Adding a new unexpected feature to an existing concept

• Examples
  ○ Neural network with long-term transient destruction of connection weights
  ○ Genetic algorithms for evolution
Creative Generation and Evaluation: Creative Autonomy

- Creative Autonomy
  - Autonomous evaluation
    - Evaluate without opinions from outside sources
  - Autonomous change
    - Changes evaluation standards without explicit directions
  - Non-randomness
    - Changes to evaluations and standards are not purely random
Creative Generation and Evaluation: Creative Autonomy

- Autonomous Evaluation
  - Creator $i$ holds $i$’s evaluation of creation $c$ from critic $j$’s perspective $E_{ij}(c)$.
  - Creator $i$ communicates with $j$ to adjust $E_{ij}(c)$ to adjust $E_{ii}(c)$ using $E_{ji}(c)$, $E_{ji}(c')$
Creative Generation and Evaluation: Creative Autonomy

- Autonomous non-random Change
  - Self confidence $M_i$ adjusts influence from external critics:
    $$M_i = \sum_{c \in \mathcal{M}_i} E_{ii}(c) / |\mathcal{M}_i|$$
    where $\mathcal{M}_i$ is a past success
  - Affinity for critic $A_j$ changes amount of influence
    - Propinquity, similarity and popularity

![Diagram showing interactions between creators and critics](image-url)
Creativity Cycle

- Create
- Evaluate
- Adjust
- Evaluation/Creation Metrics
- Evaluate
Marvin Minsky:

We don't understand the brain and we don't understand computers.

How can we say whether computers can be creative?
Relevant Fields

- Linguistics
  - Stories, jokes, poetries and etc. generation

- Music
  - Composition

- Visual art
  - Paintings and fashion designs
Music Composition

from Mozart to Iamus
A Brief History

Centuries ago: patterns and combinations

- Compose based on patterns
  - Fibonacci relations/Golden Ratio/etc.
- "Musical Dice" used by Mozart (18th century)
  - combines musical fragments randomly according to dice throws
- The Quadrille Melodist
  - Royal Conservatory of Music, 1865
  - "a set of cards that allowed a pianist to generate quadrille music"
A Brief History

Stochastic algorithms

- The Illiac Suite
  Hiller & Isaacson (UIUC, 1956)
  - Uses Markov chain in "random walk" pitch generation algorithm
  - "the first known computer-aided composition"
A Brief History

Deterministic, rule-based algorithms

● L-system by Aristid Lindenmayer, Hungarian biologist
  ○ Formal grammar rules
  ○ Originally used for modelling cell behavior
  ○ Used by Swiss composer Hanspeter Kyburz in music composition
A Brief History

Other techniques

● Riffology: random positioning of riffs
  ○ Used for improvisational music by guitar players
  ○ Uses precoded riff libraries
  ○ Randomly choose next riff based on smoothness to play

● Fractal interpolation
  ○ Pseudo randomly selects interpolation points recursively between notes
  ○ Predefined max displacement of pitch

Mostly used as aid to human composer in practice
A Brief History

AI approach: Genetic Algorithm
Genetic Algorithm

Inspired by Darwin's theory of evolution

Elements:
- A population of **samples** in the form of "gene" sequence
- **Evolution rules**: mutations, cross-overs
- **Fitness function** that takes a sample and returns a score
Genetic Algorithm

At a high-level...

1. Randomly generate an initial population
2. Evaluate the fitness of members of population
3. Select parents based on fitness, and “reproduce” to get the next generation (using “crossover” and mutations)
4. Replace the old generation with the new generation
5. Repeat step 2 through 4 till iteration N

Source: Prof. Selman's slides for CS4700
Genetic Algorithm

An example:

Source: Artificial Intelligence: A Modern Approach (3rd ed.)
A Brief History

Genetic Algorithm

● Generating Jazz Melodies
  Papadopoulos & Wiggins (Univ. of Edinburgh, 1998)
  ○ Initialization: fixed duration, pick pitches/rest at random
  ○ Genetic operators: mutation and copy (cross-over) in various forms
  ○ Fitness function: weighted sum of scores from musical structures and user specified criteria e.g. intervals, speed, pattern matching, etc.

Conclusion: "Subjectively, our system often generates interesting music patterns."
A Brief History

Genetic Algorithm

- Other attempts involve human evaluation during the evaluation process of GA

However, human evaluation is not scalable and tend to be inconsistent over time
Iamus

- Project Melomics
  - Francisco Vico, et al. (Univ. of Malaga, 2010)
  - Iamus is the name of the computing cluster

- Uses genetic algorithm
  - Generates music in increasing length and sophistication
  - $>10^9$ compositions
  - No human intervention "until the music needs to be performed"

- All in "modernist classical" style
  - Full of dissonance, but "with hints of harmony"
Iamus
How to evaluate?

- Fitness function
- Judging from reactions of the audience
  - Neurons got activated if not being told the composer is a computer
  - Impressive but "going nowhere" --- common critics received by human modernist works
  - Turing Test in music?

...is Iamus so good or "modernist" so bad?
CLARION

A system designed to replicate creativity
Defines creativity as having four components:

1. Preparation
2. Incubation
3. Illumination
4. Verification
CLARION uses a 2 layer architecture
Goal: Mimic human creativity

Test CLARION and humans in a variety of experiments such as

Free recall
Definitions of rare words
AARON

A program that paints
Written in LISP over 30 years by Harold Cohen. About 1.2 MB of code.
How is it done?

AARON has a few simple rules about the outside world.

It generates a "core figure" then traces a path around it.
AARON has grown more complex with time
Cohen does not believe AARON is creative.
Summary

- Computational creativity
- Can machines be creative?
- History of computational music composition
  - Music composition algorithms
- Iamus
- Other creative systems
  - CLARION
  - AARON
References

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- Sebastien Helie and Ron Sun. Incubation, Insight, and Creative Problem Solving.